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PURSE SEINES WITH HEXAGONAL MESH

BY

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PURSE SEINES WITH HEXAGONAL MESH

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REPORT

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PURSE SEINES WITH HEXAGONAL MESH

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Department of Fisheries

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Abstract

This report describes FTFI's research on purse seines with hexagonal mesh (H net) and contains theoretical evaluations and definitions based upon the research conducted on this type of fishing net since the project started in 1976. This fishing net has high sinking speed, achieves maximum stretched depth and performs well during fishing operations. The net shows particularly attractive characteristics under conditions of high tidal currents and large catches.

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SUMMARY

In 1975 a Russian fisheries journal published an article (ANDREEV & LJUBIMOV 1975) which described a theoretical study of hexagonal meshes and their feasibility for use in fishing nets (H net). Among other things, it was pointed out that the H net provides significant savings in material consumption. Based upon this article, the Institute for Fishery Technology Research (FTFI) embarked on a new project in 1976 in order to test this type of netting for use in purse seines.

A simple method for manufacturing net of hexagonal mesh is to modify the braiding machines for knotless netting in order to extend the joints at each bar end so that they become of the same length as the normal mesh bar. This method produces a hexagonal mesh shape with all bars of the same length but with double thickness where the joints have been extended.

For the purpose of preliminary studies in 1976, a smaller amount of H net was produced by the above-mentioned method. Strength tests showed that the mesh strength was similar to that of a normal net with rhombic mesh (F net). Three strips of H net were installed in the middle portion of a herring purse seine. The very first tests showed that the H net portion sank to a greater

depth than the rest of the seine and the best results were obtained when the H net was mounted with the longest axis of the meshes being horizontal.

A coalfish purse seine (465 x 83 m) of H net was made and tested in 1977. The mesh opening was 60 mm and the net was mounted with the longest axis of the mesh horizontal and a hanging rate of E = 0.75%. The net was tested on the coast of Finnmark and on the West coast of Norway in June-July 1977.

During these trials, fishing conditions were generally unfavorable and only 6 catches of 1-12 tons were made, altogether 45 tons.

The seine, however, showed very good operative characteristics. The sinking speed was measured at 13 m per min., which is high for a seine so lightly leaded (1.38 kg per m). In addition, it reached almost its maximum stretched depth in normal operations. Another feature was that it kept its original round shape throughout the operation without the floatline curling in any way, which is very common with seines of such low hanging. The seine was very easy to purse and the floatline was not pulled down, even at very high pursing speed. This led to the assumption that the seine was in fact pulled flat during pursing.

In the winter of 1978, the seine was made deeper by mounting an additional net panel with half mesh size (30 mm) between the two lowest net panels. In addition to making the seine deeper, the idea was that this net panel with the small mesh would provide greater water resistance than the rest of the seine, thereby giving a better bowl shape during pursing. The seine was tested during the spring in commercial coalfish fishing on the West coast of Norway, and during the period August-October on the Finnmark coast.

The seine had now become heavier to purse and the floatline was pulled down during pursing. Evidently, the water resistance had increased and a better bowl shape of the seine was achieved. In other respects, the experiment fully confirmed the tentative conclusions from the initial trials in 1977. Especially under conditions of strong tidal currents and large catches did the seine demonstrate its good properties.

During April and May, 25 catches were made on the West Coast, ranging from 0.5 to 80 tons, altogether 230 tons. These were among the best catches of the coalfish seiners in the area. The results on the Finnmark coast in August/October 1978 were also very good. The total taken with the seine in this area was 350 tons, with

single shots of up to 80 tons.

In cooperation with the fishing gear manufacturing industry, a project was started in 1979 to solve the problems of producing a H net with the same thread thickness in all bars of the mesh. Such an ideal H net without double bars would be about 25% lighter than with double bars. In addition, by modifying the braiding in the joints, it was found possible to produce a H net 17% lighter and with nearly identical thickness in all the bars. The mesh strength was nearly the same as for the F net. With available equipment, however, production was rather problematic and this type of net is therefore not yet commercially available.

A new coalfish seine (643 x 156 m) was made of this lighter type of netting. The mesh opening was 60 mm and at the floatline the net was hung in 25% (E = 0.75%). This seine also was made with 20 m panel of half mesh size (30 mm) between the two lowest net panels. The seine was tested in the fall of 1979. The sinking speed was measured at 14 m/min., which is about the same as for a comparable coalfish purse seine of F net with 2.5 times as much lead. Also, this H net seine in normal operation achieved maximum stretched depth.

The first commercial coalfish purse seine of H net was built in July 1979. Up to May 1980, the total catch with this seine was 1,500 tons of coalfish.

In early 1980, the first purse seine of H net was built and tested during the winter capelin season. The vessel quota of 1,000 tons was taken in 8 sets with catches of up to 450 tons. In addition, this seine had high sinking velocity, achieved maximum stretched depth and showed the same good operational characteristics as the H net coalfish seines. Of great importance is the fact that the floatline was not pulled down by the fish and there was no meshed capelin or bags of capelin in the webbing during hauling.

Trials conducted on sprat have shown that there is no difference in gilling between H and F net with the same mesh opening.

1. INTRODUCTION

Initial tests conducted in Norway with a purse seine took place during the winter season outside Skudeneshavn in 1876. This effort was a failure and full-scale purse fishing did not take place until the start of this century (HALAAS 1946).

During this century, purse seining has become the most significant method in Norwegian fishing. Important product improvements occurred as a result of the conversion from cotton to nylon during the 1950's and the conversion from two-boat dory seines to single-boat purse seines in early 1960. Subsequently, developments have been stagnant except for the manufacture of large nets and improvements in the quality of materials. FTFI specifically established its goal of further improving purse seines in terms of equipment cost and standardization of net construction.

Today, the basic purse seine is usually made of nylon with rhombic mesh, with or without knots. Knotless nets, however, can also be produced with other mesh shapes such as a hexagon. A Russian publication (ANDREEV & LJUBIMOV 1975) describes some theoretical evaluations of nets with hexagonal mesh (H net) and its potential use in the fishing industry. The publica-

tion specifically points to the economical advantage of the H net over that of nets with rhombic mesh (F net). Lesser deformation occurs in the H net because of force distribution and because of stretch characteristics which are different in the two main planes of the mesh.
In 1976, the FTFI started a new project to determine whether the H net was suitable for purse seines. Indeed, it appeared that this type of net featured characteristics which would be very advantageous for fishing nets.

The initial sea trials in 1976 were oriented towards determining the behavior of H nets as compared to the usual F nets. This was done by replacing three panels of a F type herring seine with H net. This configuration was tested in commercial fishing. Based upon experience gained in 1977, the seine was further developed and tested during 1978. The development and testing during this period were funded by the Foundation for Fish Detection and Research.

In cooperation with the fishing equipment industry, efforts were undertaken in 1979 to develop a lighter H net. When this effort produced satisfactory results, funding was provided by the Norwegian Bureau for Fishing Research to manufacture a large coalfish purse seine. This seine was tested during the fall of 1979 and the

spring of 1980.

Trials conducted during the 1976-78 period were carried out on the M/K Bådsvik of Rogaland, specifically leased for this purpose. The seine was furthermore provided for trials on the M/S Charles of Hammerfest during the fall of 1978. Tests of the new coalfish seine were also conducted on the M/S Christina Johnsen during the fall of 1979 and the spring of 1980.

The first capelin purse seine with H net was manufactured for the M/S Harjan of Ålesund and tested during winter fishing this year.

2. DEFINITIONS AND TECHNICAL DATA

Since F and H nets have different characteristics, it is necessary to define some terms and expressions. Definitions for nets with rhombic mesh are for knotless nets per Norwegian Standard NS 2905.

2.1. Definition of a knotless net

The direction in a F net is based upon the net setting direction and is defined as:

N direction: the direction along the net setting
T direction: the direction perpendicular to the N direction

The same definitions can be used for H nets, but since hexagonal mesh is different in width and length, a H net can also be defined as follows:

N direction: direction of longest axis in the mesh
T direction: direction perpendicular to the N direction.

2.2. Mesh size

2.2.1. Length of mesh side (bar length)

Length of mesh side in rhombic mesh is defined as the distance between two adjacent tie points, measured between centers of adjacent tie points when the net is

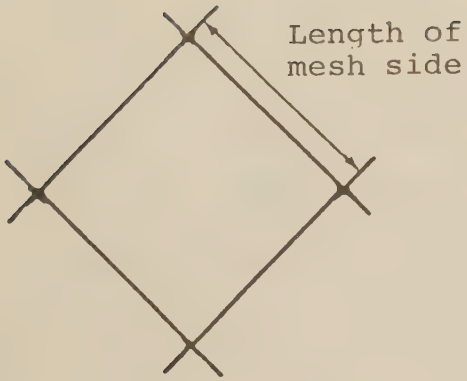

Fig. 1. Length of mesh side.
Rhombic mesh.

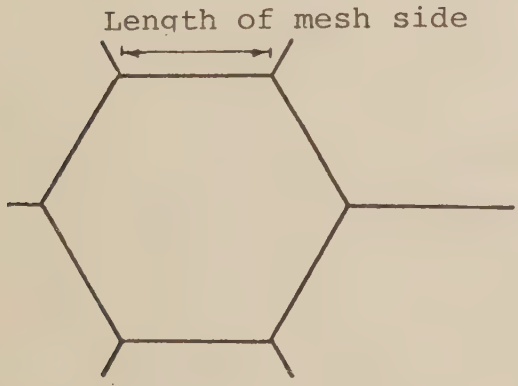

Fig. 2. Length of mesh side.
Hexagonal mesh.

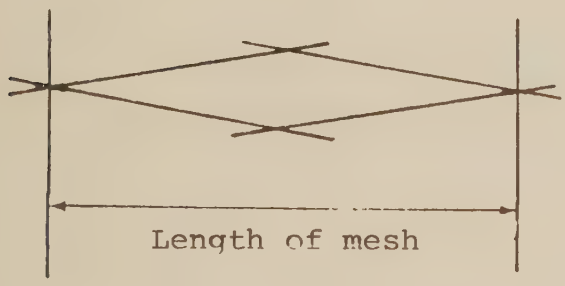

Fig. 3. Length of mesh.
Rhombic mesh.

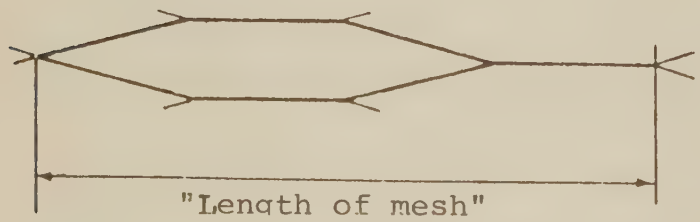

Fig. 4, "Length of mesh".
Hexagonal mesh.

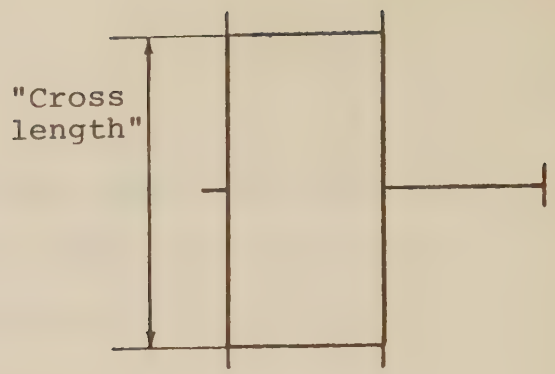

Fig. 5. "Cross length" of
nexagonal mesh.

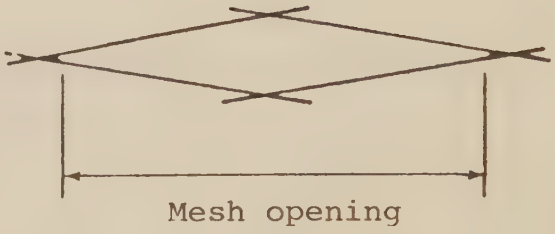

Fig. 6. Mesh opening.
Rhombic mesh.

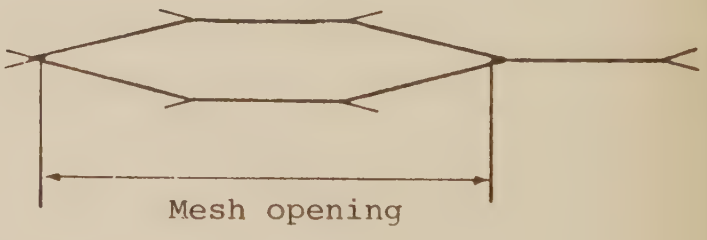

Fig. 7. Mesh opening.
Hexagonal mesh.

fully stretched (Fig. 1).

The same definitions can be used for hexagonal mesh, but for mesh of equal size (see par. 2.2.4.) the bar length in hexagonal mesh will be 2/3 of the bar length in rhombic mesh (Fig. 2).

2.2.2. Mesh length

Mesh length for rhombic mesh is defined as the distance between the midpoint of two opposing ties in the same mesh when the mesh is fully stretched along its longest axis (N direction) (Fig. 3).

For hexagonal mesh, however, the comparable dimension is defined as the distance from the end of one mesh to the joint with the next complete mesh. Mesh length in H nets is therefore equal to the length of 4 mesh sides (bar lengths) when the mesh is fully stretched along its longest axis (Fig. 4).

Therefore mesh length is used when determining hanging or counting number of mesh in a H net in the N direction. It is important to note that in hexagonal mesh, as opposed to rhombic mesh, the "mesh length" is one mesh bar longer than the mesh opening. With equal mesh opening, the mesh length in rhombic mesh is 3/4 of the

mesh length in hexagonal mesh.

2.2.3. Mesh width

In a knotless net with rhombic mesh, the mesh width (measured in T direction) is approximately equal to the mesh length (measured in N direction).

Mesh width of hexagonal mesh, however, is ½ of "mesh length" and can be defined as the length of two mesh bars measured in T direction when the mesh bars are fully stretched in that direction (Fig. 5).

2.2.4. Mesh opening

Mesh opening in rhombic mesh is defined as the internal distance between two opposing ties in the same mesh, when the mesh is fully stretched along its longest axis (N direction) (Fig. 6).

The above definition also applies to hexagonal mesh (Fig. 7).

2.3. Hanging

Proper hanging of the net from the float line is extremely important in order to achieve maximum efficiency of a seine.

Two methods are used to express the hanging coefficient (LUSYNE 1959).

2.3.1. Hanging rate (E)

Hanging rate (E) is the ratio between the length of the hanging rope (Lf) on which the net is mounted and the total length of the fully stretched net (Ls).

$$E = \frac{Lf}{Ls} \qquad (1)$$

2.3.2. Hanging percentage (P)

The hanging percentage (P) defines the length of the hanging net as a percentage of the total net length.

$$P = \frac{(Ls - Lf) \quad 100}{Ls} = 100(1 - \frac{Lf}{Ls}) = 100(1 - E) \qquad (2)$$

This expression defines the "loseness" of the hanging net.

2.4. Stretch characteristics

As indicated in the introduction, H and F nets have different stretch characteristics in the two main directions. This is shown in Fig. 8. A rhombic mesh will close irrespective of the stretch direction. A hexagonal mesh, however, has different deformation depending upon the stretch direction. In the N direction, it will close equal to rhombic mesh, but in the T direction, it will assume a rectangular shape. The

setting direction of a purse seine of a H net is therefore of utmost importance to the operational characteristics of the net.

2.5. Hanging depth

The term "hanging depth" can be defined as the total depth of a net when all mesh have achieved the form as attached to the hanging rope. The ratio between hanging depth (Df) and total depth of the stretched net (Ds) is expressed as:

$$d = \frac{Df}{Ds} \qquad (3)$$

whereby d is defined as coefficient of actual depth. The coefficient of actual depth for the F net is the same, irrespective of setting direction:

$$d_F = \sqrt{1 - E^2} \qquad (4)$$

For the H net, however, the coefficient of actual depth depends upon the setting direction.

With horizontal mounting (N direction horizontal) the coefficient

$$d_{HN} = 2\sqrt{E(1 - E)} \qquad (5)$$

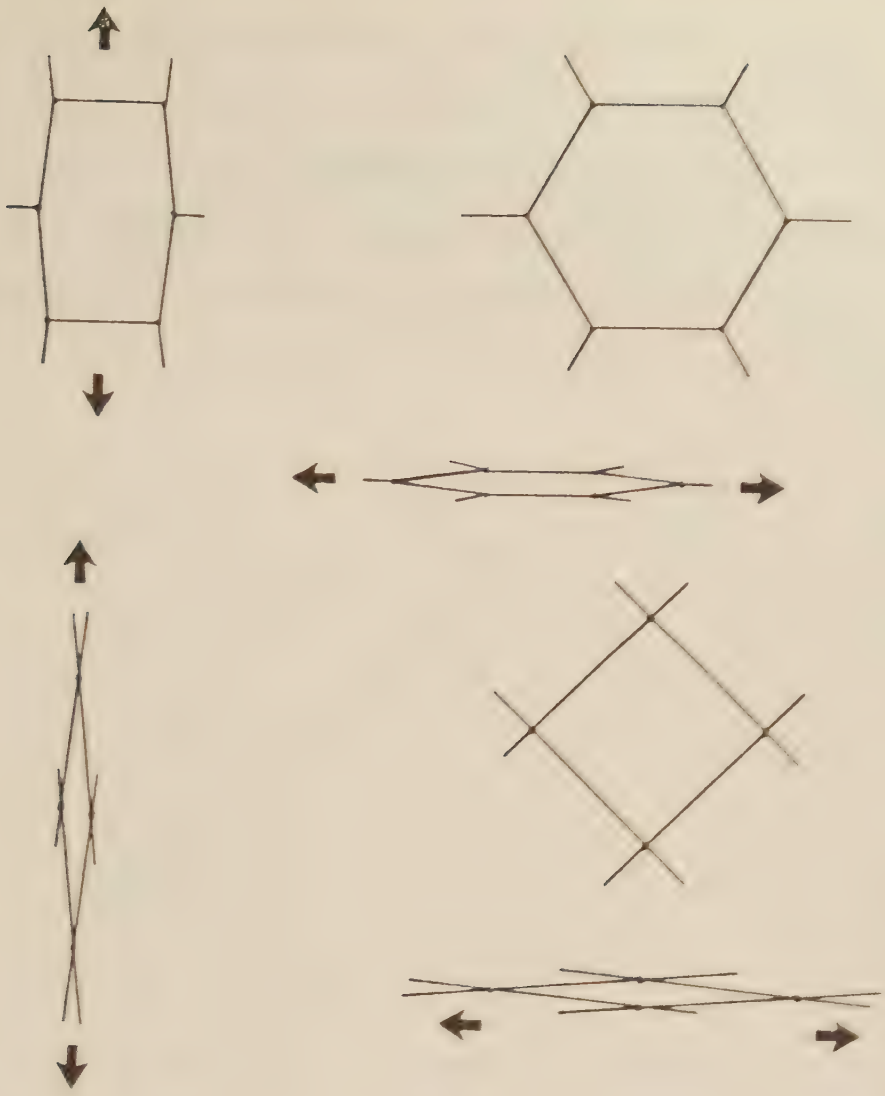

Fig. 8. Deformation of H and F net stretch in the two main directions.

With upright mounting (T direction horizontal) the coefficient

$$d_{HT} = \sqrt{\frac{1 - E^2}{2}} + 1 \qquad (8)$$

Fig. 9 shows the coefficient of actual depth as a function of hanging ratio. The curve for the F net is a circle where the increase in coefficient of actual depth is proportional to the hanging ratio. The coefficient of actual depth for a horizontally mounted H net is equal

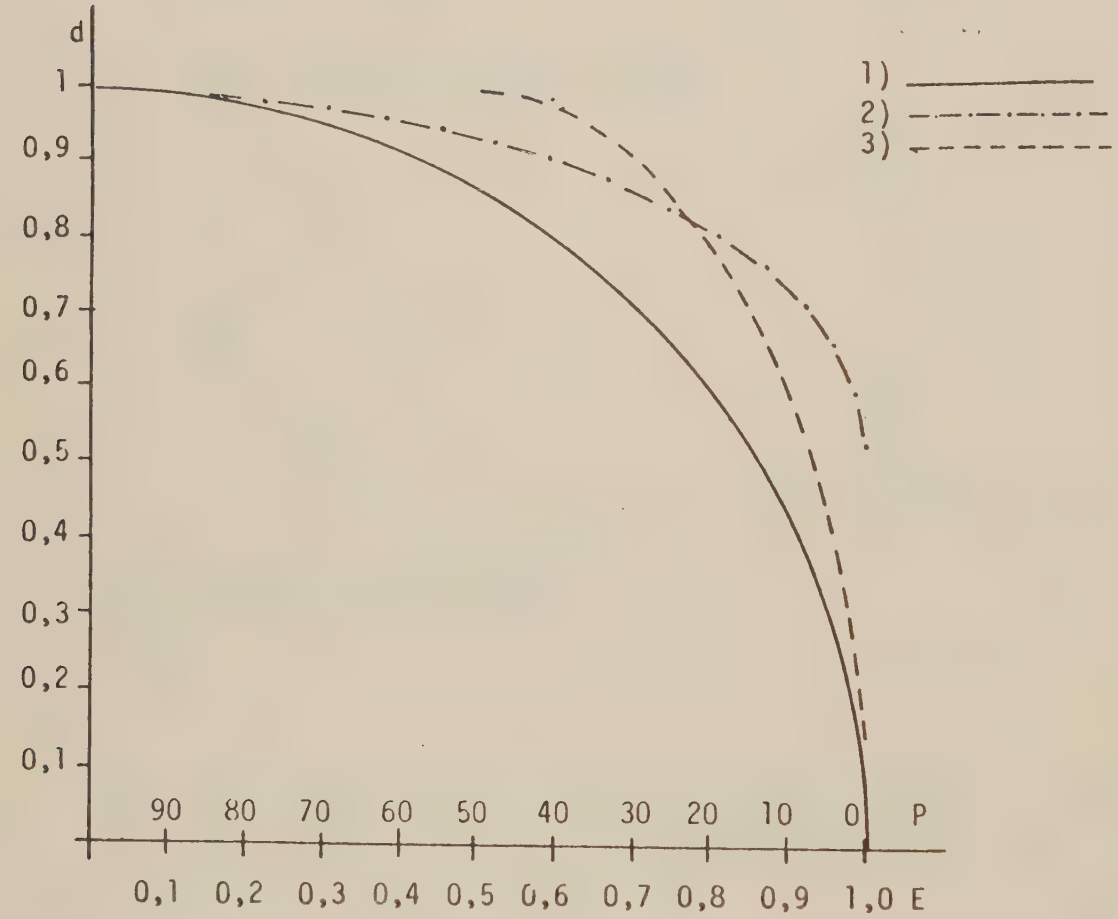

Fig. 9. Relationship between hanging percentage (P)/ hanging ratio (E) and coefficient of actual depth (d):

1) F net
2) H net with T direction horizontal
3) H net with N direction horizontal

to that of a F net, namely 0 at 0% hanging. It increases faster than that of a F net and reaches a coefficient of actual depth of 1 at 50% hanging, i.e. fully stretched depth. Conversely, vertically mounted H nets achieve a coefficient of actual depth of 0.5 at 0% hanging, which increases towards 1 at 100% hanging.

As shown in Fig. 9, a H net mounted horizontally has greater hanging depth than a F net with equal stretched depth, irrespective of the hanging rate. The increased depth required for a F net as compared to a H net to achieve equal hanging depth can be determined from equations 3 through 5:

$$D_{SF} = D_{SH} \frac{2\sqrt{E_H(1 - E_H)}}{\sqrt{1 - E_F^2}} \qquad (7)$$

whereby D_{SF} and D_{SH} are the stretched depths for horizontally mounted F and H nets respectively. E_F and E_H are the hanging rates for the two types of nets.

Where a combination F and H net seine is used, e.g. F net in the lower part and the rest H net, care must be exercised in order to ensure that the depth relation between the two nets is proper in order to avoid deformation at the joint.

Normal hanging of the lower F net is 35 to 45%. By applying the hanging rates for these two nets against 25% (E_H = 0.75) for the H net in equation 7, we obtain:

$D_{SF} = D_{SH} \cdot 1.041$ for $E_F = 0.55$ and

$D_{SF} = D_{SH} \cdot 1.14$ for $E_F = 0.65$

This means that the F net at these hanging rates must be 4.1 and 14% deeper than the H net, with E = 0.75, to achieve equal hanging depth.

2.6. Net area

Fig. 10 illustrates two nets of equal mesh opening, with hanging that produces maximum net area, 29.3% (E = 0.707) for F net and 25% (E = 0.75) for H net. The dotted rectangles define the area of each mesh.

The area of one mesh varies with the rate of hanging. For rhombic mesh, the following equation applies:

$$A_F = 4b^2E\sqrt{1 - E^2} \qquad (8)$$

where A_F = area, b = length of mesh side and E = hanging rate.

Similar for hexagonal mesh:

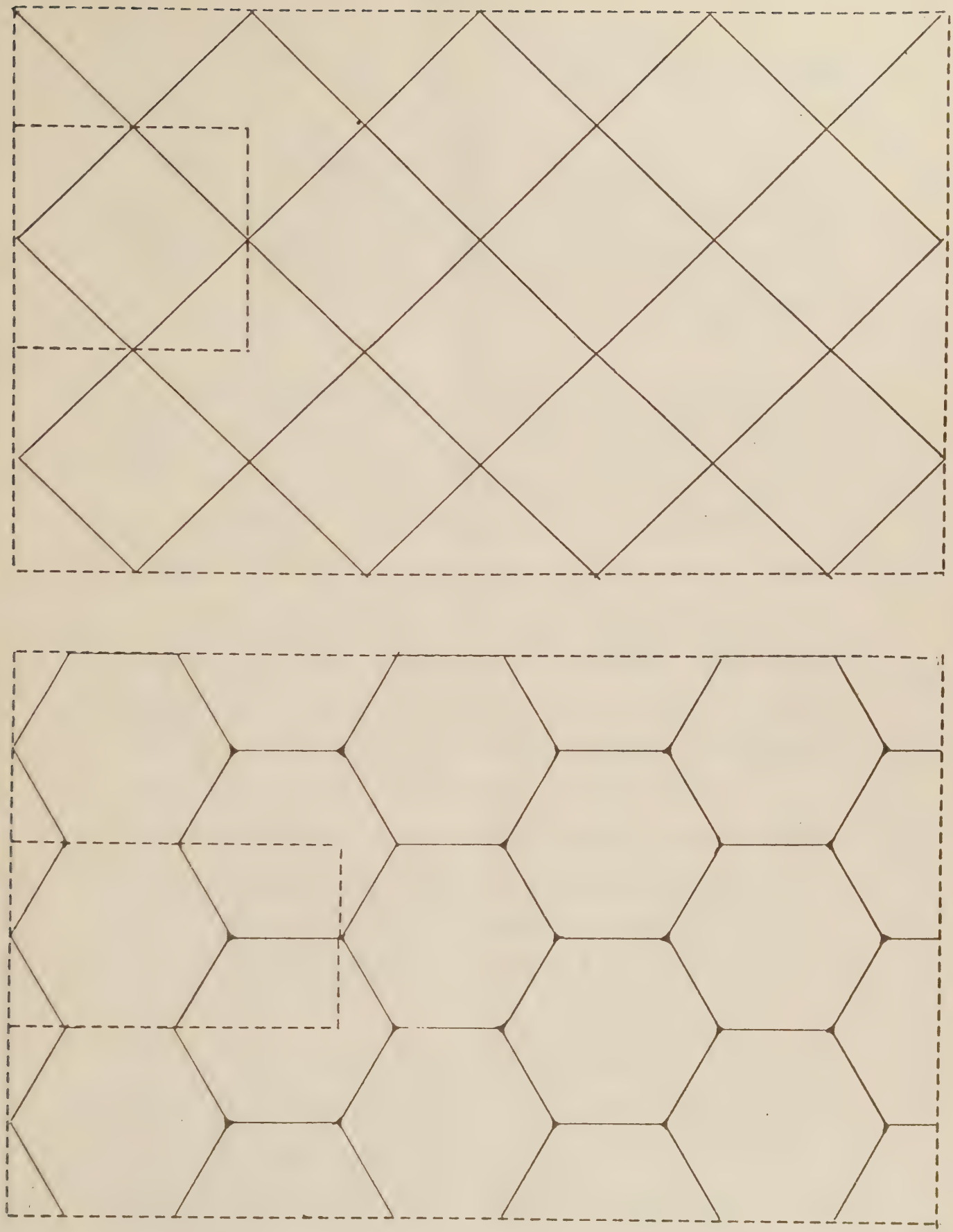

Fig. 10. F and H net with same mesh opening (60 mm).

$$A_H = 16a^2E\sqrt{E(1 - E)} \qquad (9)$$

where A_H = area and a = length of mesh side. Area of a net consisting of M mesh deep and N mesh long is determined by multiplying mesh area by the number of mesh (M·N). (10)

In the example of Fig. 10, both mesh types have the same mesh opening, namely 60 mm. Length of mesh side is 30 mm for the F net and 20 mm for the H net. Both nets in Fig. 10 have an equal area of 18,000 mm^2. To cover the area with F net requires 4 mesh in length and 2.5 in depth, i.e. 10 mesh total. H net requires 2.887 mesh length and 3 mesh depth, i.e. 8.661 total. Assuming that all mesh sides require an equal amount of thread, the thread consumption for F net is 10·4·30 = 1,200 mm and for H net 8.661·6·20 = 1,039.3 mm. In summary, this means that two nets with hanging which provides maximum net area, equal mesh opening and thread thickness, the F net requires 15.5% more thread than the H net in order to cover an equal area.

Fig. 11 gives some comparisons as to how hanging length, hanging depth and area for rhombic and hexagonal mesh vary as a function of the hanging rate. The dotted lines delineate area. By calculating L_f,

D_f and A, the mesh opening for both mesh types is defined as 60 mm.

As shown in Fig. 9 as well, the hanging depth for both mesh types increases as a function of increased hanging percentage. Hanging depth increase fastest for hexagonal mesh and reaches full stretched depth at 50% hanging, as opposed to rhombic mesh, which requires 100% hanging to achieve hanging depth equal stretched depth. It is therefore not practical to exceed 50% hanging for hexagonal mesh. It would be required to crimp the mesh sides to achieve this.

Norwegian F net seines have extensive hanging, a hanging rate of E = 0.55 (45%) is normal. High hanging rate, i.e. lesser hanging, is more economical, as the maximum net area for a given amount of net is achieved at 29.3% hanging (E = 0.707), but the hanging depth is reduced. Coefficient of actual depth at hanging of 29.3% is 0.707. A H net (horizontally mounted) provides greater correlation between hanging rate and maximum net area at high hanging depth. A H net has the greatest net area with E = 0.75 (25% hanging) and coefficient of actual depth at this hanging is 0.866. Hanging of 25% for a horizontally mounted H net renders good net economy as well as high hanging depth.

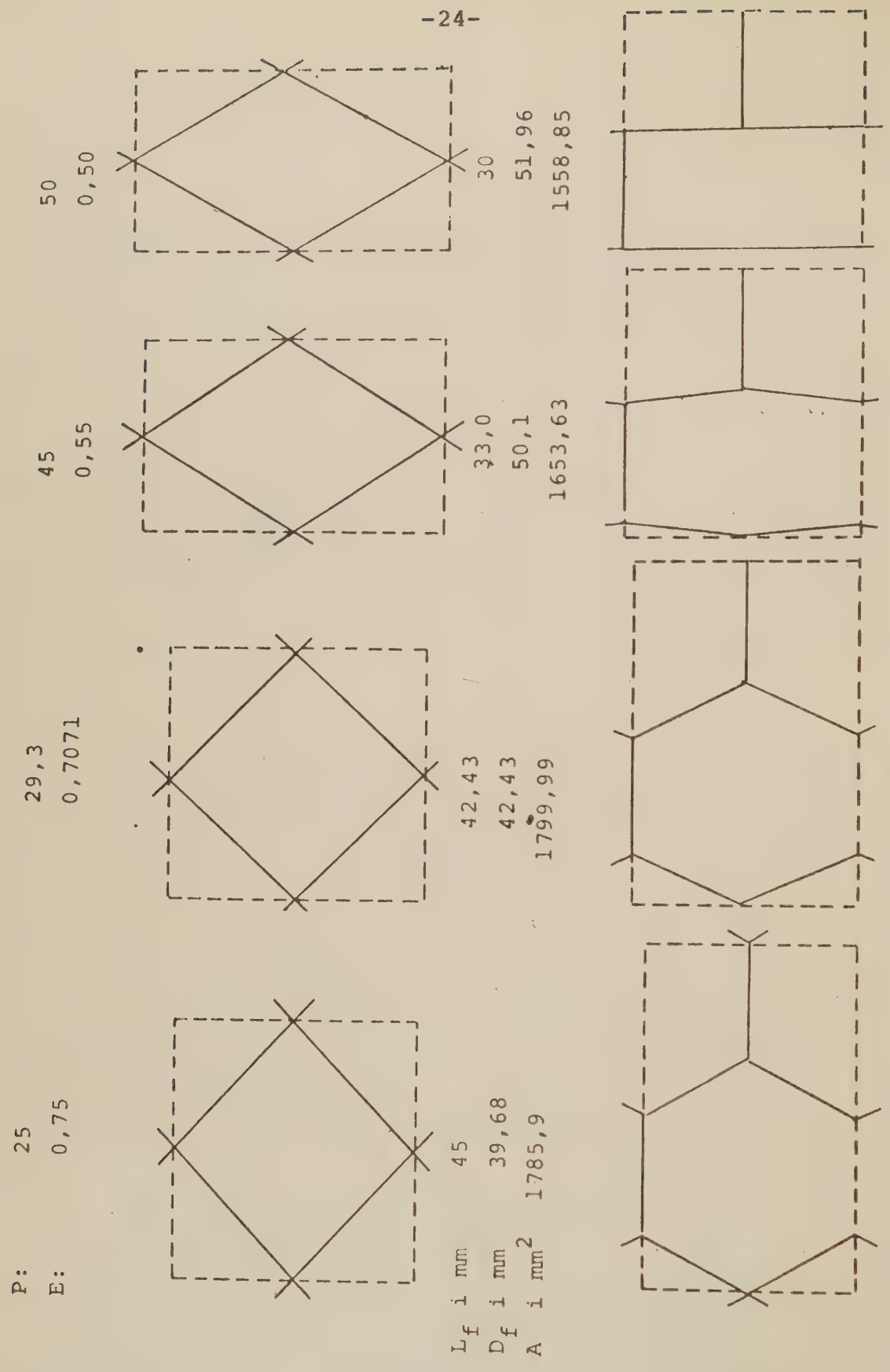

Fig. 11. Comparative examples of hanging length (Lf), depth (Df) and area (A) for rhombic and hexagonal mesh (60 mm mesh opening) by different hanging percentage (P)/hanging ratio (E).

Comparing the area of a hexagonal mesh net at E = 0.75 with the area of a rhombic net at E = 0.55 (Fig. 11), it is shown that the area for hexagonal mesh is 25.7% greater than that of rhombic mesh.

3. PRODUCTION METHODS AND STRENGTH MEASUREMENTS

Today's production methods limit the production of hexagonal net to knotless net. The simplest production method of H net is to elongate the thread joints for each "overturn" so that these have the same length as the mesh sides. This method produces hexagonal mesh shapes where all mesh sides are of equal length, with double thread thickness where the joints are elongated (Fig. 12). This product provides an equal amount of thread per running meter as the equivalent rhombic net, and with an equal number of mesh per net panel.

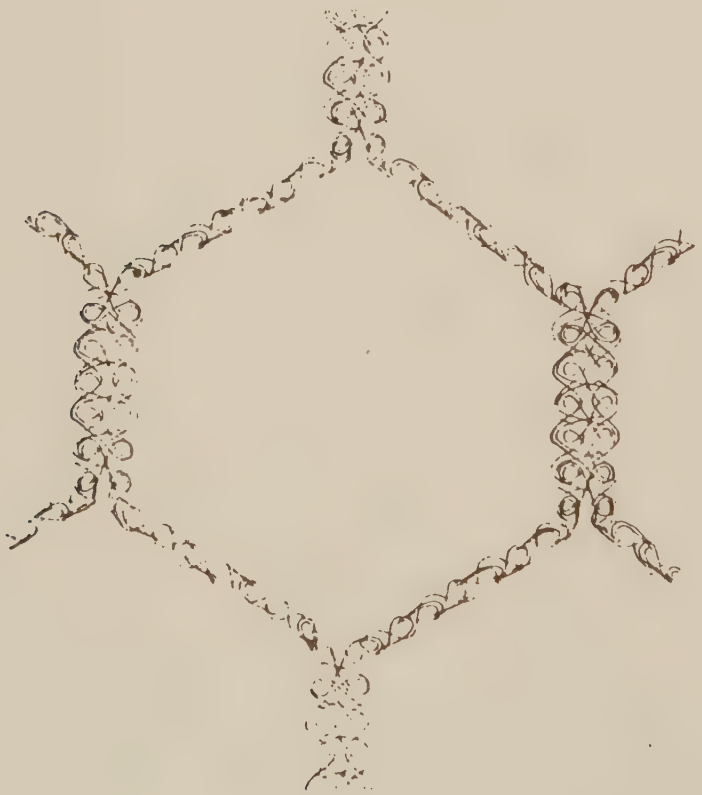

Fig. 12. Production of H net on Raschel netting machine.

An ideal H net without double mesh sides is 25% lighter than one with two double mesh sides. In cooperation with the fishing net industry, development efforts were begun in 1979 to develop a H net with equal amount of thread in all mesh sides. Initial attempts were made on a conventional Raschel machine by producing tight joints on single mesh sides and loose joints on the double mesh sides. This method rendered 7-8% reduction in net weight. These results were not satisfactory and an additional production method was developed. A summary description follows.

Production of knotless mesh in accordance with the Raschel method is achieved by knitting of three threads. Two threads are filler threads while the third is the knitting thread. It is possible to split the knitting thread on an 8-track Raschel machine. This production method is based on the principle that single mesh sides are produced as described above, but as the machine progresses to join individual mesh, the knitting thread is split in such a way that 1/3 is continuous as knitting thread while 2/3 converts to filler thread. After the joints are completed, the machine continues the operation in a conventional manner. Since the knitting thread constitutes the major part in terms of weight and volume while the filler thread is straight,

this method reduces the double mesh sides in both weight and volume. This production method yielded a weight reduction of approximately 17% in comparison to H net with double mesh sides. Due to currently available production equipment, problems still remain with this production method and this type of net is therefore not commercially available at the present time.

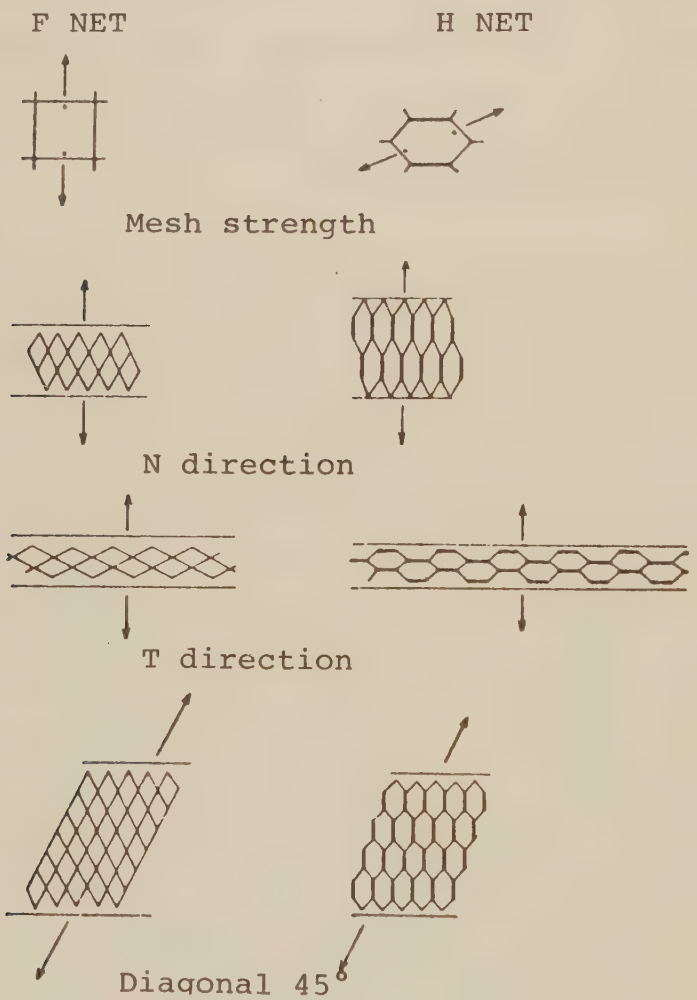

Fig. 13. Testing breaking strength of F and H net with Istron.

To determine breaking strength of the H net, tests were conducted for the H net as well as for a F net with knotless mesh.

Breaking strength of individual mesh was determined as well as breaking strength of the total net measured in N, T and diagonal direction (Fig. 13). The usual method used when measuring mesh breaking strength is to suspend one mesh between two fixed points. Total net strength is measured by suspending a net section between two fixed plates. The tests are conducted at the Norwegian Textile Institute on an Istron stretch force machine. All measurements are conducted with wet nets.

Test results of the original H net manufactured in 1976 yielded equal mesh strength for H and F nets. Breaking results for both H and F nets indicated that both were strong in the N direction and weakest diagonally. A comparison of the test results showed that the H net was weaker than the F net in the N and T direction, 14.5% and 21.8% respectively. The H net was 16.4% stronger than the F net in the diagonal direction.

Test results of the new H net with 17% less material

in thread size #4.5 was compared with normal H net with thread size #6 with two double mesh sides. Both H nets had a mesh strength comparable to that of F net with equal thread size. Test results of break tests of the H panels show comparable strength in the N direction, while in the T direction the net with thread size #6 was 49% stronger than the one with #4.5 thread size, while 12.9% weaker in the diagonal direction.

The two types of H net were subsequently mounted in a new test seine and evidence clearly demonstrated that the net with #6 thread size was weaker than the one with thread size #4.5. This may be the result of different knitting methods for the two test types, specifically at the mesh joints as most test failures occurred there.

There is a clear need to define how different production methods affect breaking strength of fishing nets in all directions and to develop testing methods that will yield more accurate test results of practical value than the test methods currently employed.

4. DESCRIPTION OF TEST NETS AND FIELD NETS

4.1. Preliminary testing

As previously indicated, preliminary tests with H nets were initiated in 1976. The purpose of these tests was to compare the characteristics of the H net with that of conventional F nets. To achieve this in the simplest and most economical manner, three test panels (47 x 90 m) of H net were inserted in the center of a conventional herring seine. These test panels had mesh openings equal to the F net, but with two double mesh sides in all mesh. The test panels were first mounted and tested with the T direction horizontal (standing panels), subsequently removed, rotated and mounted with the N direction horizontal (lying panels). In both cases, the test panels were mounted to the mesh of the rhombic net with hanging of 25%, while the hanging of the F net was 45%.

Fourteen test shots were conducted where operable net depth of the H net was measured with a Benthos depth recorder (bathypymograph). The automatic recorder is attached to the net and prints net depth from the time the recorder is submerged until complete net retrieval. Shape and deformation of the net mesh were surveyed by means of a submarine-type television camera (UTV).

Trials showed that on the average the H net with vertical meshes and the H net with horizontal meshes sank deeper, 9.6% and 12.3% respectively, than the F net. It was further observed that during retrieval the floatline of the H net with horizontal meshes was maintained easier than the other portions of the seine. On the other hand, there was no obvious difference in floating capacity between the H net with vertical meshes and the F net.

The TV records show that the hexagonal mesh remained more open and stretched, resulting in more even net distribution, than the rhombic net. With panels lying down, the hexagonal mesh was virtually stretched to a rectangular mesh at maximum operable depth. A hanging rate of 25% appeared to be sufficient.

4.2. Initial coalfish seine (H net)

The preliminary test results were sufficiently encouraging to warrant production of a complete H type coalfish seine in 1977. Initially, the seine was constructed as a seine of four panels (N direction horizontal) with equal mesh size (60 mm). The stretched depth was 83 m. Fig. 14 shows a final configuration of this seine. The H net was produced in a normal tying machine for knotless net and therefore had double thread thickness in the mesh sides. The H panels were attached in stretched shape to a border of the F net. The border was mounted to the float line with 25% hanging. The lower panels of the conventional F net had a stretched depth equal to the H panels at the joints of the two panels. Lead cable was used with the exception of the center and bottom sections (37 m) of the seine where conventional lead was used. This lead cable was tied to the lower edge of the skirt in a conventional manner. Total lead weight was 717 kg.

Based on the test results obtained in 1977, the seine was converted during the winter of 1978. It was made deeper by mounting a long net panel between the two lower end panels. This panel had half-size mesh (30 mm). This net panel had a depth of 20 m for the full length of the seine (Fig. 14).

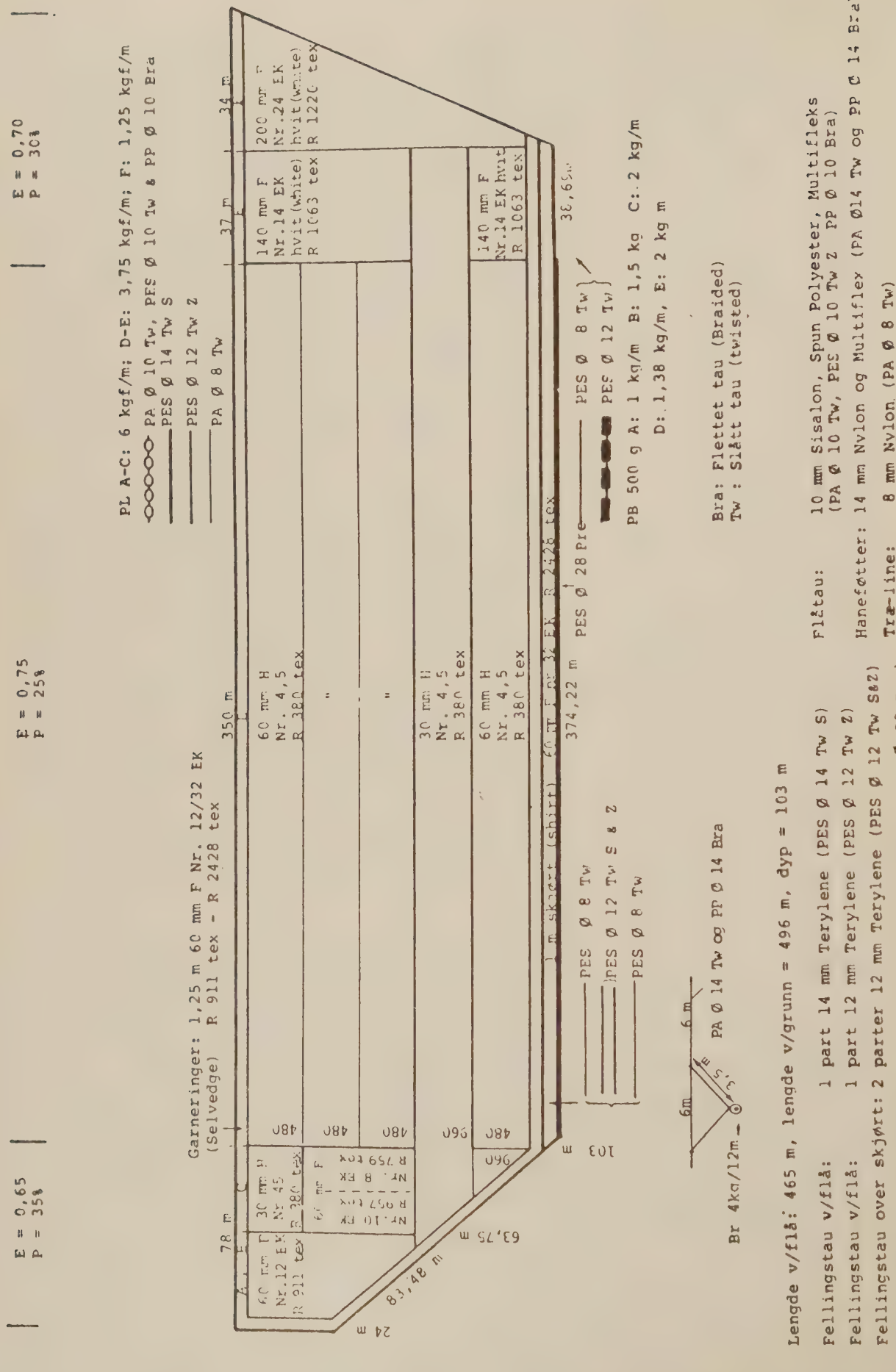
E = 0,65
P = 35%
E = 0,75
P = 25%
E = 0,70
P = 30%
PL A-C: 6 kgf/m; D-E: 3,75 kgf/m; F: 1,25 kgf/m
PA Ø 10 Tw, PES Ø 10 Tw & PP Ø 10 Bra
PES Ø 14 Tw S
PES Ø 12 Tw Z
PA Ø 8 Tw
Garneringer: 1,25 m 60 mm F Nr. 12/32 EK
(Selvedge) R 911 tex - R 2428 tex
350 m
37 m
34 m
78 m
24 m
63,75 m
103 m
374,22 m
60 mm H Nr. 4,5 R 380 tex
140 mm F Nr.14 EK hvit (white) R 1063 tex
200 mm F Nr.24 EK hvit(white) R 1220 tex
30 mm H Nr. 4,5 R 380 tex
48A
96A
PES Ø 8 Tw
PES Ø 12 Tw S & Z
PES Ø 28 Pre
PES Ø 12 Tw
PB 500 g A: 1 kg/m B: 1,5 kg C: 2 kg/m
D: 1,38 kg/m, E: 2 kg m
Bra: Flettet tau (Braided)
Tw : Slått tau (twisted)
PA Ø 14 Tw og PP Ø 14 Bra
6 m
Br 4kg/12m
Fliåtau: 10 mm Sisalon, Spun Polyester, Multifleks
(PA Ø 10 Tw, PES Ø 10 Tw Z PP Ø 10 Bra)
Haneføtter: 14 mm Nylon og Multifley (PA Ø14 Tw og PP Ø 14 Bra
Trælline: 8 mm Nylon (PA Ø 8 Tw)
Lengde v/flåå: 465 m, lengde v/grunn = 496 m, dyp = 103 m
Fellingstau v/flå: 1 part 14 mm Terylene (PES Ø 14 Tw S)
Fellingstau v/flå: 1 part 12 mm Terylene (PES Ø 12 Tw Z)
Fellingstau over skjørt: 2 parter 12 mm Terylene (PES Ø 12 Tw S&Z)
Fellingstau v/ grunn: Sekv. D 1 part 28 mm blykabel (PES Ø 28 Bra)
1,38 kg pr. m. A-C og E-F 1 part 12 mm.
Terylene (PES Ø 12 Tw)

Fig. 14. The first coalfish purse seine with H net.

In June and July of 1977, the seine was tested during the coalfish season along the coast of Finnmark and the west coast. Subsequent to conversion of the seine in 1978, tests were conducted on the M/K Bådsvik during coalfish fishing on the west coast during the months of April and May. During August and October, the seine was tested onboard the M/S Charles during the coalfish season on the coast of Finnmark.

The trials during 1977 were originally planned for the coast of Finnmark where they were started. Some schools of coalfish were located near Magerøy, but they were too deep (50 to 70 m). Only boats with deep nets were able to catch. Four shots were made but without success (except for 300 kg of fish in one catch). Two shots for cod were made in Varangerfjord and yielded a catch of 50 and 900 kg. A shallow shot at 20-35 m damaged the lower panels of the seine.

Four shots were made for coalfish in Ramsøyfjord. One shot produced 1.8 metric tons.

During three days along the coast of Florø, 9 shots were made, 6 of which yielded catches of 1 to 12 ton for a total of 45 ton. Here, coalfish were not located as deep (from the surface down to 45 m), but the fish

were small (30-40 cm). The catches in this area were better with fewer unsuccessful shots compared to other purses in the same area with seines of corresponding size. Most shots in this area were done in shallow water. Much of the fish was small for the net mesh used (60 mm) but little gilling was observed in the hexagonal mesh, except during one shot at night in shallow water when the purse wire got caught on the bottom and caused the seine to collapse. The fish that became gilled measured between 30 and 34 cm.

Initial tests after conversion of the seine were conducted in March 1978 near Måløy. Fishing was poor and the coalfish was located near the sea bottom. Five shots produced two catches of 3 and 3.5 ton.

The tests continued during April and May along the coast of Rogaland. During April, 17 shots produced 13 catches of 0.5 to 30 ton for a total of 100 ton in Boknafjord. Difficult tidal currents and fish location in shallow water caused several empty shots and some net damage.

At the end of May, the coalfish activity picked up at Utsira. During 14 shots, 9 catches produced from 0.5 to 80 ton, for a total of 130 ton of coalfish, plus 0.5 ton of mackerel. The above were the better catch

results for appr. 30 boats operating in the area. Difficult sea current conditions prevailed also in this area.

Good results were obtained by the M/S Charles during August-October fishing at the Finnmark coast. Single catches of 80 ton were achieved.

During the trials on the M/S Badsvik, recordings were taken of net depth and sinking speed. Fig. 15 shows two test samples taken before the seine was modified. The recorder (Benthos) was attached to the center ring of the seine. With the (A) shot pursing was started immediately after the net was set, while pursing was delayed 18 minutes in shot (B). The seine sank fastest for the first 50 m (12.5 - 14.5 m/min), decreasing its speed thereafter. If the seine is allowed time to sink further before pursing is started, fully stretched depth of 80 m is achieved (B), while shot (A) achieved 67 m only.

After modification and installation of small mesh panels in the seine, the sinking speed was measured at appr. 12 m/min for the first 50 m. Records taken showed that the seine achieved virtually full stretched depth (appr. 100 m) when allowed time to sink.

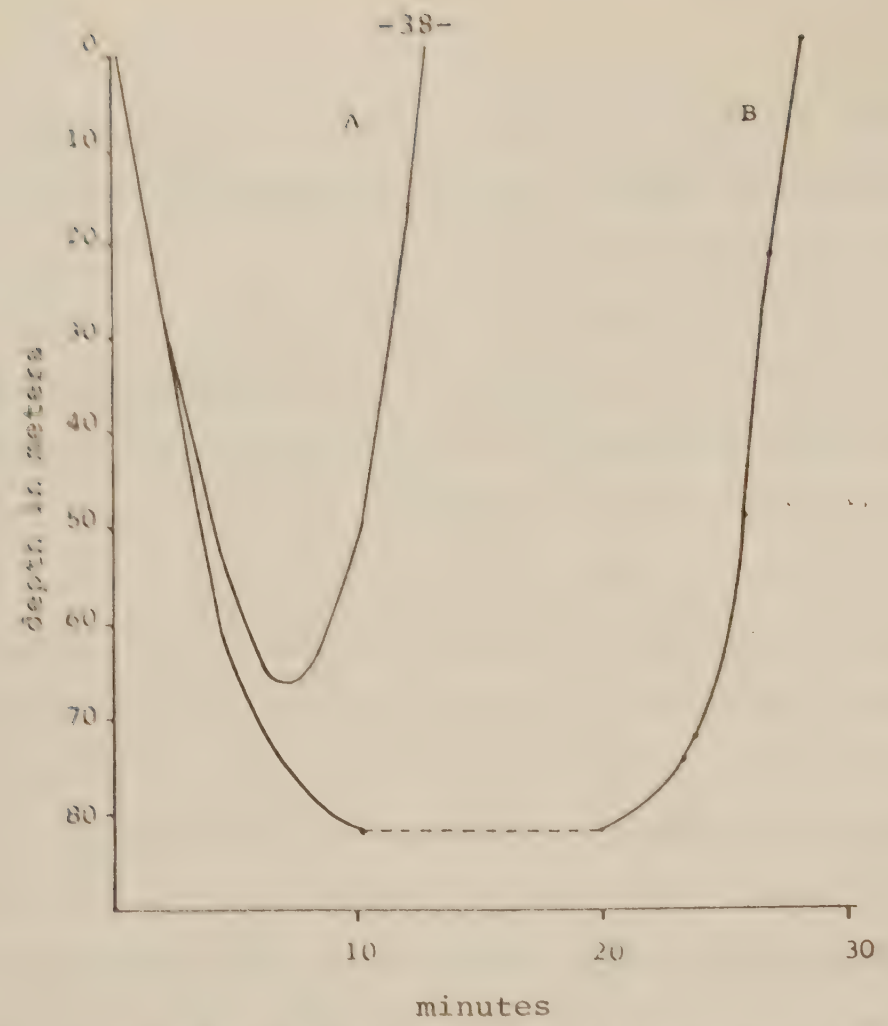

Fig. 15. Depth of the first coalfish purse seine with H net.
A: Pursing starts immediately after shooting.
B: Pursing starts 18 min. after shooting.

Tension and retrieval speed of the purse wire were measured by a test set developed by FTFI's Shipping Section (BJØRSHOL 1979). Since tension in the purse wire increases with increased retrieval speed, the below-average values are taken with the seine 50% retrieved.

Measurements taken prior to modification of the seine

indicate a tension in the purse wire of appr. 0.6 to 0.7 ton m/min at a retrieval speed of 35-40 m/min. In 1978 after modification with small mesh panels, the tension had increased to 0.8-1.2 ton at the same retrieval speed. The pull tension for a comparable F net was measured at 1.6-1.8 ton at a retrieval speed of 35-40 m/min.

During the 1977 trials, the float line did not submerge at high retrieval speeds. Subsequent to modification with smaller mesh panels, it was noted that the float line submerged, indicating that the water resistance had increased.

The seine performed well during all trials. Shooting went well without snags developing in the net. The seine maintained its round shape during the shot. Good performance was achieved during conditions of strong tidal currents and large quantity catch. The fish kept clear of the net sides during most of the retrieval.

At the interface line between the H and F net, bags formed in the net during retrieval. Apparently, this was due to tension differential between the H and F net. At times this caused a problem in transferring

the fish to the lower net during retrieval.

As previously indicated, the seine was damaged several times. Tears would usually occur in a diagonal line following the mesh bars. Conventional mending is not possible on this net, but conventional sewing is simple and is actually faster than for F nets since the mesh maintain better openings.

The first coalfish seine of H net for commercial use was manufactured during the summer of 1979 for Knut Ellingsvåg, Averøy, owner of the M/K Vingholm. This seine also has lying panels. Length at float line is 490 m and depth is 87 m. During the latter half of 1979, 900 ton was caught and 600 ton during the winter of 1980. These catches were substantially larger than for other boats fishing the same fields with conventional nets. The performance results obtained confirmed the outstanding properties of the H net.

4.3. New coalfish seine with equal thickess mesh bars

As mentioned earlier, during the spring of 1979 a fishing net manufacturer succeeded in producing a H net which was 17% lighter and with appr. equal thickness thread in all mesh bars. During the summer of 1979, a large coalfish seine was manufactured of this net.

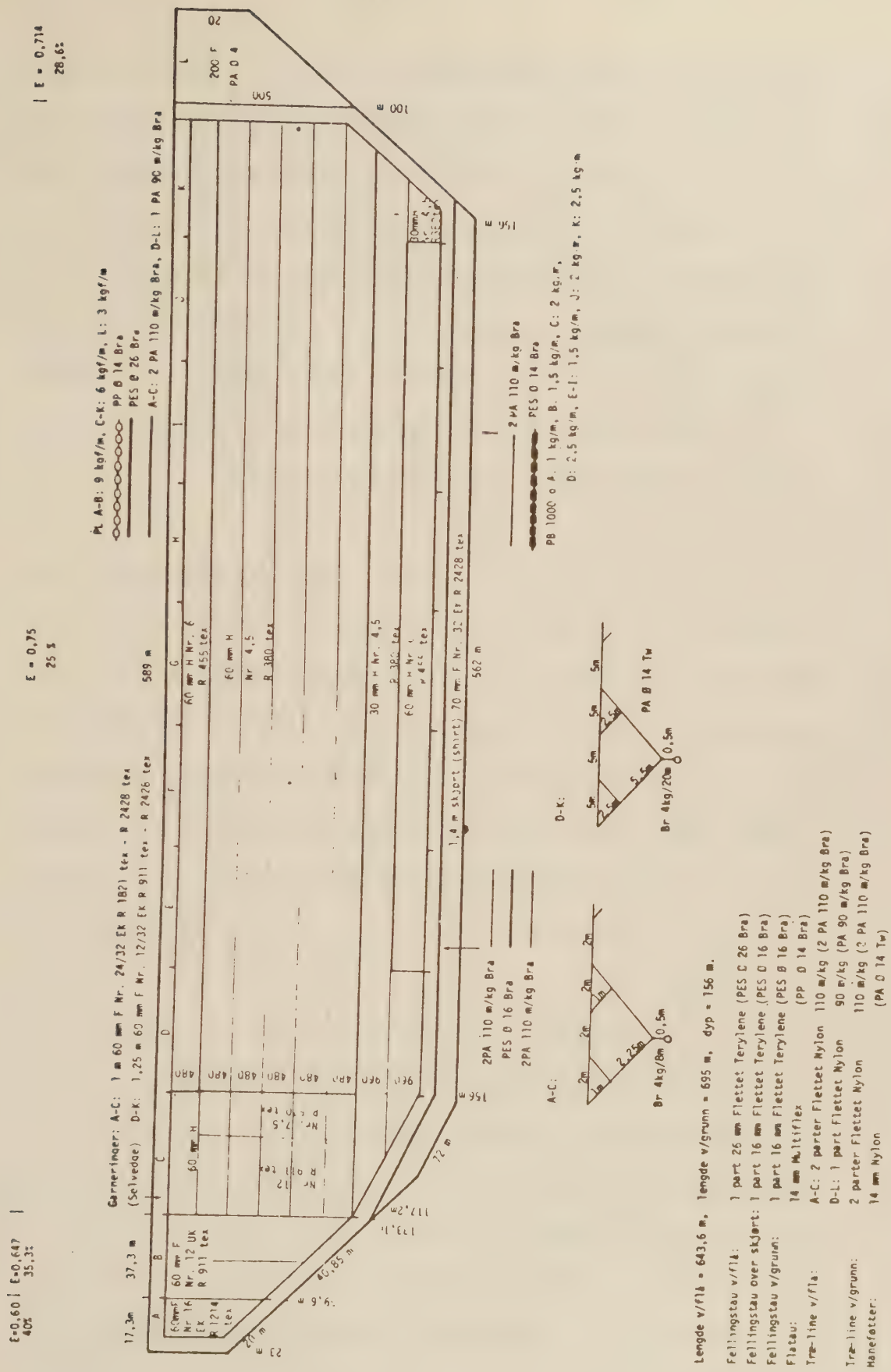
Garneringer: A-C: 1 m 60 mm F Nr. 24/32 Ek R 1821 tex - R 2428 tex
(Selvedge) D-K: 1,25 m 60 mm F Nr. 12/32 Ek R 911 tex - R 2426 tex
PE A-B: 9 kgf/m, C-K: 6 kgf/m, L: 3 kgf/m
PP Ø 14 Bra
PES Ø 26 Bra
A-C: 2 PA 110 m/kg Bra, D-L: 1 PA 90 m/kg Bra
2 PA 110 m/kg Bra
PES Ø 14 Bra
PB 1000 o.Æ: 1 kg/m, B: 1,5 kg/m, C: 2 kg/m,
D: 2,5 kg/m, E-I: 1,5 kg/m, J: 2 kg/m, K: 2,5 kg/m
2PA 110 m/kg Bra
PES Ø 16 Bra
2PA 110 m/kg Bra
A-C:
D-K:
Br 4kg/0m
Br 4kg/20m
PA Ø 14 Tw
Lengde v/fla = 643,6 m. lengde v/grunn = 695 m. dyp = 156 m.
Fellingstau v/fla: 1 part 26 mm Flettet Terylene (PES C 26 Bra)
Fellingstau over skjørt: 1 part 16 mm Flettet Terylene (PES C 16 Bra)
Fellingstau v/grunn: 1 part 16 mm Flettet Terylene (PES B 16 Bra)
Flatau: 14 mm Multiflex (PP Ø 14 Bra)
Tre-line v/fla: A-C: 2 parter Flettet Nylon 110 m/kg (2 PA 110 m/kg Bra)
D-L: 1 part Flettet Nylon 90 m/kg (PA 90 m/kg Bra)
Tre-line v/grunn: 2 parter Flettet Nylon 110 m/kg (2 PA 110 m/kg Bra)
Manefotter: 14 mm Nylon (PA Ø 14 Tw)

Fig. 16. New coalfish purse seine with H net with approximately the same thickness in all bars.

Fig. 16 shows the configuration of this seine. All H net with #6 thread has double thread thickness in each mesh. In addition, there is a small mesh panel inserted in the seine at a depth of 20 m between the two lower net panels. At each end of the seine, this panel is extended all the way down to the pull rings. The idea behind this is to utilize the hydrodynamic resistance in the small mesh net to ensure that the wings of the seine project deeper during the pursing.

In the initial coalfish seine, bags developed at the joints of the F and H net panels after the seine was pursed. Theoretically, this condition should be avoided by inserting sufficient F net to ensure that both net types have the same hanging depth. How much deeper the F net must be can be determined from equation (7) (see page 19). In this seine the F net is 15% deeper than the H net at the joints between the two panels.

As reinforcement of the H net, braided nylon rope 75 m/kg is sewn into the edge of each mesh panel. The same rope was used in the horizontal plane between the lowest and next to lowest panels.

The edge rope is braided terylene. The seine is

mounted in accordance with the "West Coast" method in that the trailing rope of braided, white nylon is tied directly to the edge rope.

The skirt sections are secured in that each panel is split and fixed with rings secured with thin wire. Common lead is used throughout. During the fall trials of 1979 the total lead weight was 1,242 kg. It was subsequently increased to 1,713 kg during the modifications of the seine during the winter of 1980.

The seine was tested on board the M/S Christina Johnsen during the 1979-80 winter coalfish season off the coast of Finnmark. Unfortunately, the seine was delivered too late to be used during this season. During the spring season of 1980, coalfish was running too deep to catch. The same also applied to other boats in the same area.

Measurements of sinking speed and actual depth were taken with a Furuno acoustical depth recorder. This allows for continuous recording on board the ship as the seine is sinking. It is also possible to attach the system to the regular sound for direct reading on recording paper (BELTESTAD, CHRUICKSHANK & OLSEN 1979). Measurements of tension and retrieval speed were conducted with the same test set as previously described.

Comparable recordings were taken for the new seine as well as the conventional coalfish seine. This seine is 865 m long and 170 m deep. The seine, which is a conventional F net, has hanging of 45% (E = 0.55). The seine is equipped with approximately 3,000 kg lead. The bottom part of the seine was leaded with appr. 8 kg/m.

Fig. 17 shows the results of two measurements of sinking speed and operational seine depth for the new seine purse of H net. Diagrams show the depth from the time of entry into the water until the time of purse retrieval. Instrument (1) is mounted to the 12th ring, (2) is mounted to the 22nd ring and (3) is mounted to the 31st ring.

Fig. 17A shows a shot as it is normally done on the M/S Christina Johnsen. Pursing started 4 min. after setting and normal speed was maintained. The middle portion of the seine has even sinking speed (appr. 13.3 m/min) up to 80 m and thereafter decreasing speed after pursing has started. Average sinking speed from 0 to 100 m is 12.7 m/min. Maximum operating depth was measured at 116 m. The reason for 83 m only on the front is due to the seine touching the bottom at that point.

Fig. 17B shows the pursing operation starting 16 min.

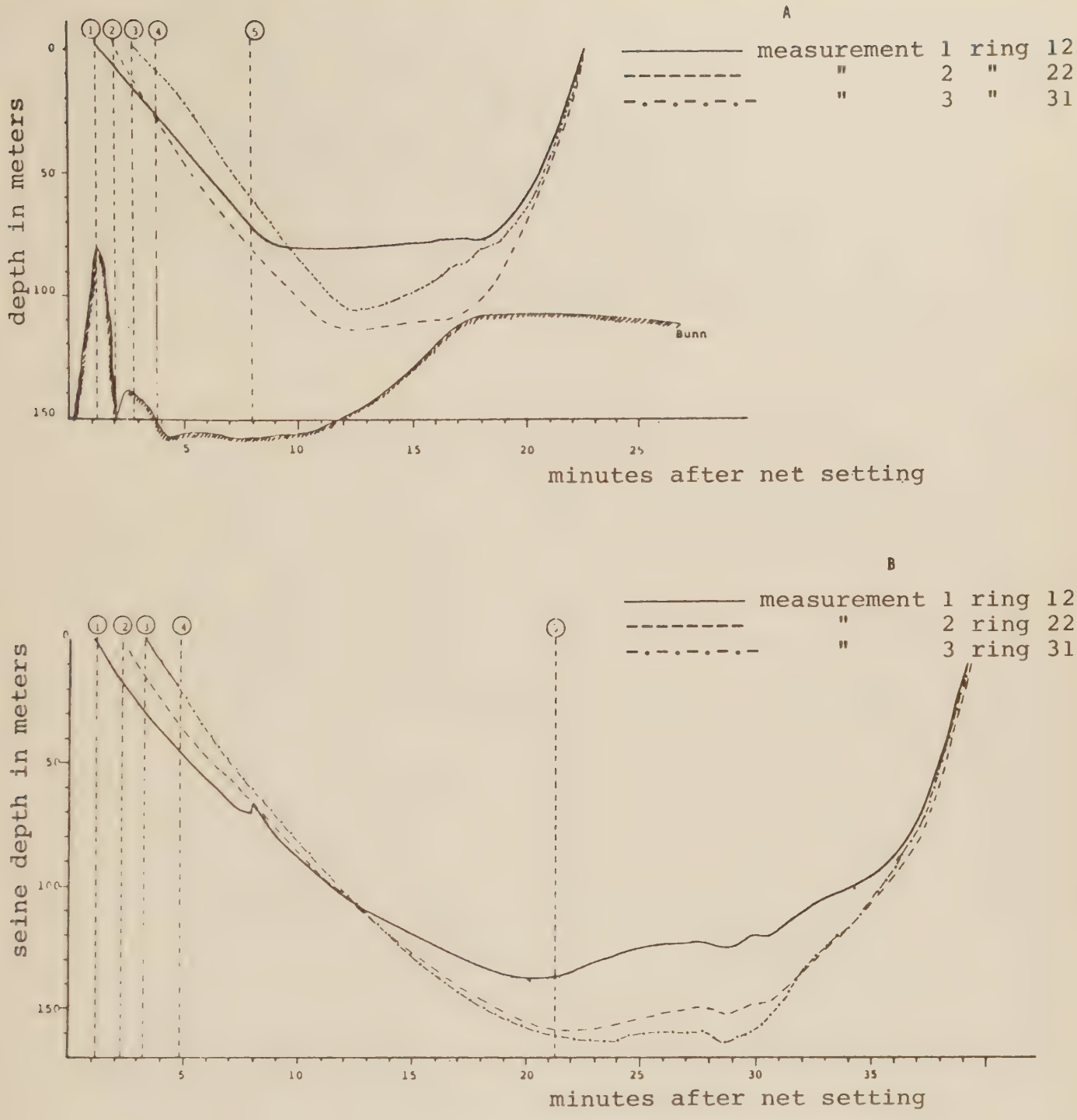

Fig. 17. The depth from two sets with coalfish purse seine with H net.

1-3: The instruments enter the water.
4: Shooting completed.
5: Pursing starts.

after the seine is set. The middle and back part of the net sinks at a steady speed of 10.9 m/min. up to 100 m depth and thereafter this speed decreases gradually. Maximum operable depth was 165 m. This depth equals full stretched depth. The leading panel sinks at a lower rate and achieves only 140 m depth.

Fig. 18 shows two comparable coalfish shots as done on the M/S Christina Johnsen. Only two instruments were used and depth reading was manual. Instrument (1) was attached to the 26th ring (near middle of seine) and (2) was attached to the 44th ring (6 rings from end). Each shot is performed as closely as possible as in Fig. 17.

In Fig. 18A, pursing was started appr. 4 minutes after the net was set. The middle part of the net has an average sinking speed of 14.3 m/min. Comparing this speed with that of Fig. 17A shows that the F net sinks faster than the H net for 0-80 m, but that the speed decreases faster after 80 m. After pursing is started, the H net continues to sink while the sinking speed of the F net decreases rapidly. Maximum operating depth is appr. 100 m.

Fig. 18B shows a deep shot where pursing is started after

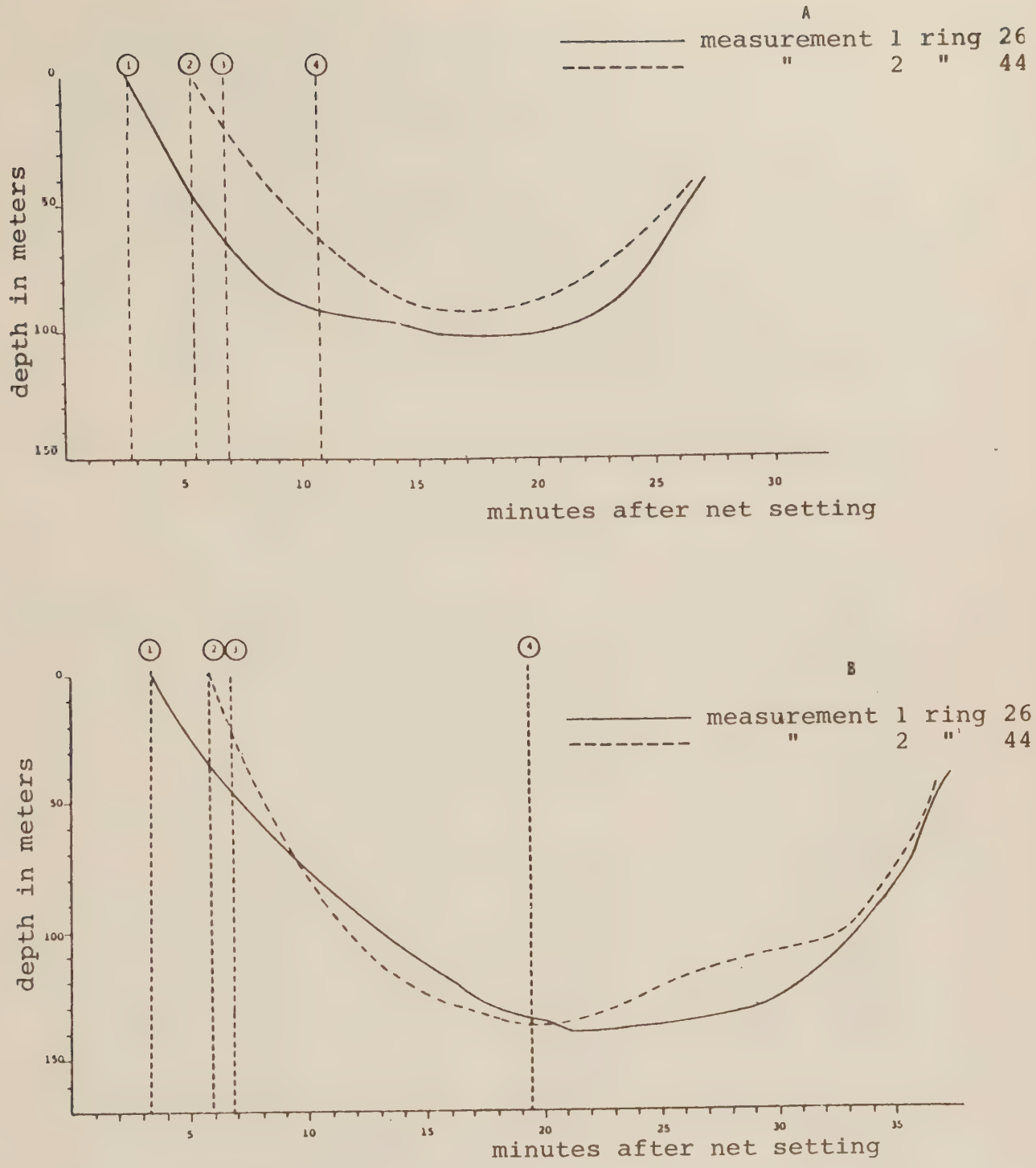

Fig. 18. The depth from two sets with coalfish purse seine with F net on the M/S Christina Johnsen

1-2: The instruments enter the water.
3: Shooting completed.
4: Pursing starts.

14 minutes. The seine had stopped sinking at that point. Average sinking speed for the middle part is 11.4 m/min (0-80 m) and 10 m/min (0-100 m). Comparing Fig. 17B and 18B indicates comparable sinking speed for the two nets. Maximum operating depth for the F net is 140 m as opposed to 165 m for the H net, even though the F net is 14 m deeper.

Tension in the pursing wire was appr. 30% less for the H net at equal retrieval speed.

Even though no catch was made with the H net, indications are that no bags formed at the joints between H and F net panels, though clear proof of this can only be obtained during an actual cash.

4.4. Capelin purse seine (H net).

As a result of the success with H net in coalfish seines, there has been increased interest on the part of commercial fishermen in trying these nets for other types of fishing. During the fall of 1977, Jan Johansen, owner of the M/S Harjan, inquired at FTFI about assistance to develop and manufacture a capelin seine with H net.

Fig. 19 shows the arrangement of this seine. All H net is of conventional type with two double mesh bars per mesh. Net panels are mounted lying down (N direction

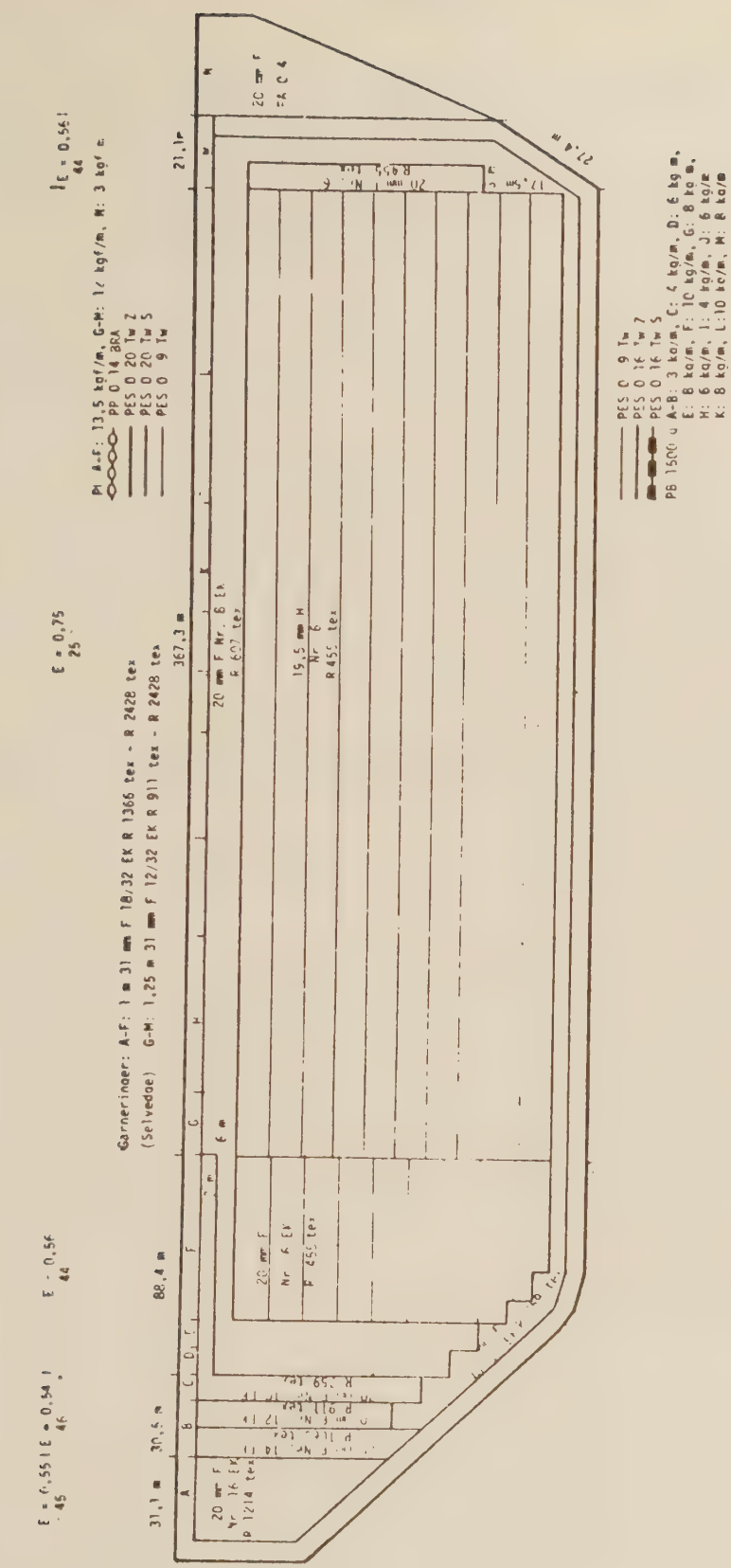
Garnerinoger: A-F: 1 ■ 31 mm F 18/32 EK R 1366 tex - R 2428 tex
(Selvedge) G-M: 1,25 ■ 31 mm F 12/32 EK R 911 tex - R 2428 tex
PE A-F: 13,5 kg f/m, G-M: 17 kg f/m, N: 3 kg f/m
PP D 14 BRA
PES D 20 Tw Z
PES D 20 Tw S
PES D 9 Tw
PES D 16 Tw Z
PES D 16 Tw S
PB 1500 u A-B: 3 kg/m, C: 4 kg/m, D: 6 kg m,
E: 8 kg/m, F: 10 kg/m, G: 8 kg m,
H: 6 kg/m, J: 4 kg/m, J: 6 kg/m
K: 8 kg/m, L: 10 kg/m, M: 8 kg/m
E = 0,75
25°
E = 0,56
44
E = 0,56
44
E = 0,551
45
E = 0,54
46°
88,4 m
31,1 m
30,5 m
367,3 m
21,1 m
20 mm F Nr. 6 Ea
R 607 tex
15,5 mm H
Nr 6
R 455 tex
20 mm F
Nr 6 Ea
R 455 tex
20 mm F
Nr 16 Ea
R 1214 tex
Lengde v/flå = 535 m, lengde v/grunn = 602 m, dyp = 156 m.
Fellingstau v/flå: 2 parter 20 mm Terylene (2 PES D 20 Tw Z og S)
Fellingstau v/grunn: 2 parter 16 mm Terylene (2 PES D 16 Tw Z og S)
Flåtau: 14 mm Multiflex (PP D 14 Bra)
Tre-line: 9 mm Terylene (PES Ø 9 Tw)
Nanefetter: 20 mm Nylon (PA Ø 20 Tw)

Fig. 19. Capelin purse seine with H net.

horizontal) and are hanging from the float line at 25% (E = 0.75). At the bottom, the H net is reinforced with an inlay of 6 mm braided terylene rope for each 2 1/2 net ring.

Also, in this seine consideration is given to the difference in hanging depth for the two types of net. After calculation per equation (7), the F net should be 4.5% deeper than the H net at the transition when both achieve hanging depth. Since the F net at the transition is also mounted lying down, therefore more difficult to stretch in the T direction, it was decided to apply 10% more F net.

Manufacturing of the seine is done in a different manner in order to avoid the displacement of meshes. This method makes the production simpler and, as a result, faster than traditional methods. The total amount of the lead used in the seine was 4.2 tons.

The capelin seine was delivered after the season had started. The M/S Harjan used the seine to catch the balance of its quota (10,500 hl). The operation took place in Varangerfjord. A total of 8 shots were made, 3 of which yielded 3,000, 3,500 and 4,500 hl, or a total of 11,000 hl. There were no faulty shots.

Two of the shots were estimated to contain 6,000-7,000 hl each. The capelin was very heavy, but the seine did not collapse. Only after most of the H net was retrieved, it was noticed that these were large catches. The seine did not collapse until the transition from H to F net, and some catch was lost. Net catch for these two shots was 4,500 and 3,500 hl, respectively.

Recordings show that the sinking speed was normally 16 m/min. from 0-100 m, but one shot sinking speed was recorded at 22.7 m/min. (0-100 m). Maximum operating depth was recorded at 151 m. This is approximately equal to the stretched depth of 156 m. Test recordings from other capelin and mackerel seines do exist. The M/S Vestfart has a capelin seine of comparable size. Sinking speed for this seine has been recorded at 14 m/min. (0-100 m) and maximum operating depth of 130 m. During the fall of 1979 a series of recordings was made of the sinking speed of a mackerel seine

on the M/S Libas, with a total lead weight of 7.5 ton. The highest sinking speed recorded was 17 m/min. (0-80 m). Operating depth could not be recorded as all shots were done in shallow water.

Even though tension and retrieval speed have not been recorded for the purse wire, indications are that the seine is significantly lighter to purse than a conventional seine of F net.

Otherwise, all indications are that the seine showed good catch and operating characteristics. Shooting was easy with no fouling of the net. The seine maintained its round shape and the float line did not submerge during pursing. During retrieval, minimum gilling of capelin occurred and no bags were observed at the F net/H net joint lines.

4.5. Gilling

Since the mesh of a H net will remain more open during fishing operations than that of a F net, it was assumed that more fish would get gilled in the net. In order to clarify this subject, tests were conducted during the spring of 1980 on sprat in a floating basin. Two comparable tests were conducted with H and F net of comparable mesh opening, 16.4 and 19.2 mm. All

nets had the same thread thickness of #1.5. Each net was mounted transversely to the floating basin. The H net was mounted lying down with hanging of 25% and the F net mounted upright with hanging of 45%. The floating basin was drained and the sprat chased towards the net for a period of appr. 10 minutes.

Fig. 20 shows the lateral distribution of sprat in the basin and the amount of sprat gilled in the different net types. Only the smallest sprat got gilled in the test nets. There appeared to be no significant difference between the different net types as far as gilled sprat is concerned. Measurements of the nets with 19.2 mm mesh indicate that the average mesh size is 19.07 for H net and 18.71 mm for F net. This explains the difference in length distribution and medium length of the fish caught in the two net types. It can be concluded that there is no or very little difference in gilling between H and F nets of equal mesh size.

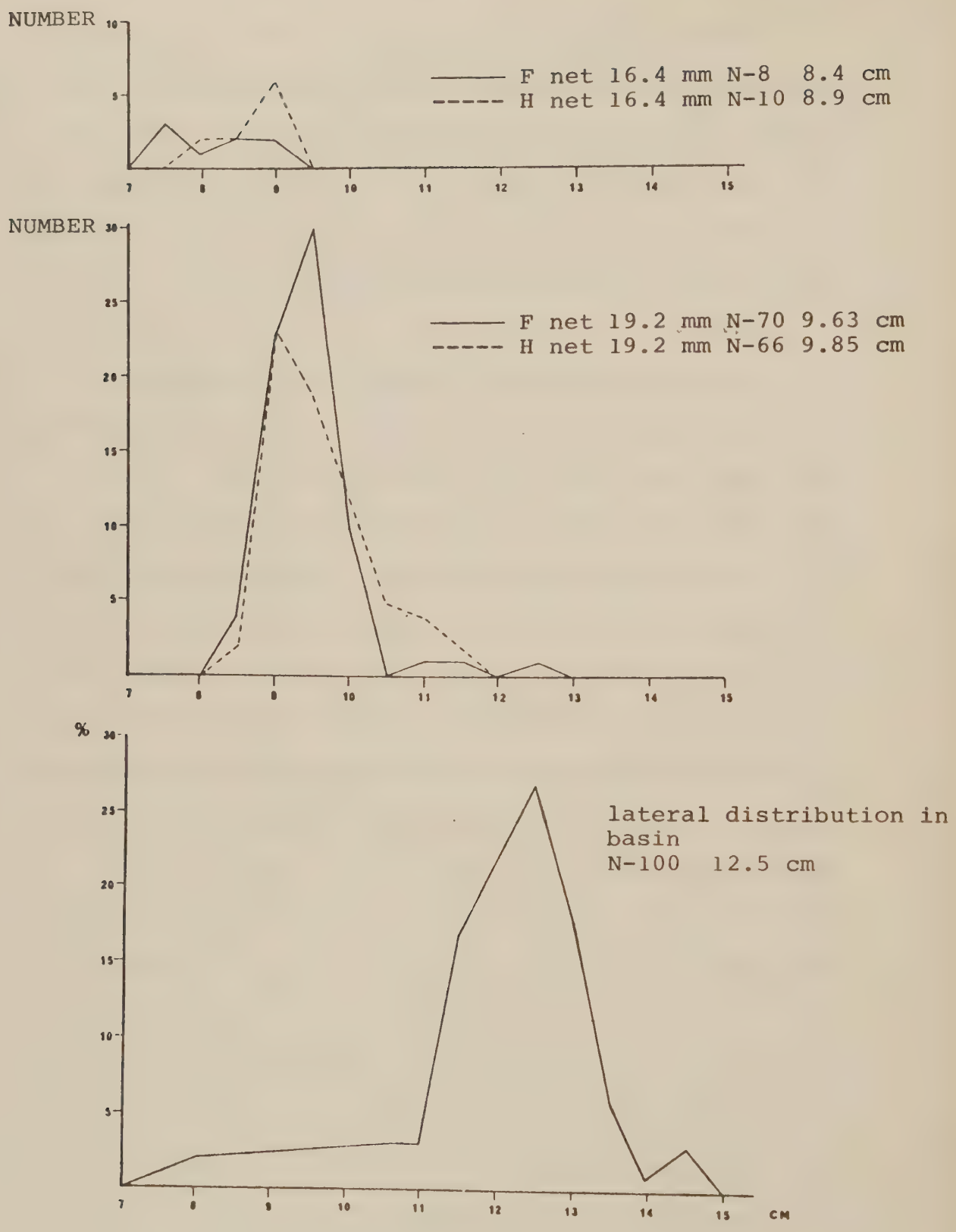

Fig. 20. Length distribution of sprat in the floating pen and gilled on 16.4 and 19.2 mm H and F net.

5. DISCUSSION

Sinking depth of a seine is dependent upon mesh size, thread thickness, hanging rate and lead weights. Sinking speed will vary with the method of setting and ocean currents.

Sinking speed of the first coalfish purse seine seemed very high for such a light lead line (1.38 kg/m). Installation of the small mesh panels did not reduce the sinking speed significantly.

If one compares the results of the recordings of Fig. 17 and 18, it appears that the two nets have comparable sinking speed. Even though the two nets are not directly comparable, it appears that the H net has higher sinking speed than the F net since the F net has 2.5 times more lead than the H net.

The capelin H net showed higher sinking speed compared to the conventional capelin and mackerel nets of the M/S Libas.

If it is correct that H nets have higher sinking speed, this appears to be due to the fact that the mesh in H nets provide more opening and therefore lesser water resistance during stretch in the vertical plane.

Another factor that will reduce sinking speed when the seine approaches hanging depth is the horizontal stretch (HAMRE 1963).

This is greater in F net than in H net with the actual hanging rate. Sinking speed will therefore reduce earlier for F net than for H net. This is confirmed by the depth measurements shown in Fig. 17 and 18. The H net sinks at an even rate, while the sinking speed for F nets decreases with increasing depth.

As indicated, when seines of H net reach full stretched depth, F nets achieve only 80-85% stretched depth which is appr. the hanging depth. This can be observed in Fig. 10. To achieve full stretched depth for a hexagonal mesh at 25% hanging, the mesh length need only reduce 1/3. In order to achieve the same for rhombic mesh at 45% hanging, the total mesh hanging length must reduce. This explains also that the float line on a H net is less tangled than that which is normal for a F net. The fact that H nets reach full depth shows also that 25% hanging is sufficient. In addition, catch results confirm these findings.

Tension measurements in the purse wire show that H net is very easy to purse. This is because stretch in the

vertical direction will force the mesh open while P net will tend to close. H nets therefore have less water resistance.

The unusual low tension in the purse wire measured on the first coalfish seine in 1977 and the condition that the float line did not submerge at high speed retrieval led to the assumption that the purse was too flat. It was also the experience that the fish disappeared through the bottom of the seine. In order to achieve maximum round shape of the seine and early closure of the bottom, panels with reduced mesh were inserted between the lower end panels. The increased tension in the purse wire measured in 1978 and the fact that the float line now disappeared, indicates that the water resistance has increased and that a better shape of the seine exists. Catch results in 1978 support this conclusion. How deep this resistance panel should be and where it should be located in the seine is not completely clear. It is possible that a stretched depth of 5-10 m is sufficient.

Braking panels were not installed in the sprat seine as it was assumed that the fine mesh of the total net was sufficient to create high water resistance.

The fact that H nets have less water resistance is probably also the reason that the seines maintain a good shape even during high tidal currents.

The right depth ratio between F and H nets at the transition has still not been determined. Theoretically this ratio will be right when both nets have equal hanging depth. Trials show this to be insufficient. This is probably due to the fact that H nets sink close to full stretched depth, while F nets do not exceed the hanging depth.

As indicated earlier, both the coalfish and sprat avoided the seine walls. The sprat did not move down with the net and little sprat was discovered in bags at the panel joints during retrieval. There are further indications that the coalfish survival is better in H nets. This is due to the fact that the seine maintains its round shape during the total catch.

Trials with sprat did not indicate any difference in performance between F and H nets. Since the fish tends to avoid the seine walls, it appears that less gilling can be expected in H nets than in F nets with the same mesh size. This is confirmed in part by the test shots made outside Florø, but a definitive

answer will not be available until test shots are made during the summer fishing season.

Catch results obtained with coalfish seines and sprat seines of H net design must be categorized as very good. Tests have shown that seines of H net are at least equal to conventional seines in terms of catch characteristics and ease of operation. It is considered that a seine of H net goes 15-20% deeper than the comparable F net with considerable cost reduction even for mesh with double mesh bars. If production methods can be established for an ideal H net, it is possible to save 25-30% in material cost. It appears that it is also possible to reduce lead weight accordingly.

The high sinking speed and good operational characteristics of the sprat seine of H net indicate favorable uses for herring and mackerel fishing. This would have a significant economic impact as one seine could be used for several fish types. This means that eventually boat owners will no longer need different kinds of seines.

The H net is already in full use with at least 10 nets in existence or on order. Many capelin, mackerel and sprat seines have been manufactured and are on order.

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